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INVESTIGATION OF THE RHYTHM OF SLEEP AND WAKEFULNESS IN CREWS OF THE SPACESHIPS "SOYUZ 3-9" BEFORE, DURING AND AFTER EXPOSURE TO SPACEFLIGHT

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Abstract: During the course of preparations for spaceflight and during its execution the crews of the "Soyuz-3-9" exhibited similar disturbances in the rhythms of sleep and wakefulness (phase shift, change in ratio from 2:1 to 6:1) associated, on the one hand, with the influence of modified daily schedules (primarily of the migrating type), and on the other hand, neuropsychic stress and weightlessness. The dynamics of higher nervous activity of these cosmonauts during space flight revealed four stages: first (from the zero to the second day) -- a deterioration in the general feeling of well-being, performance and sleep; second (from the second to the sixth days) -- recovery and retention of functional state and performance of the cosmonauts to a high level; third (from the seventh day) -- a gradual decline in functional state and performance of the cosmonauts; fourth (one or two days prior to the landing) -- a brief increase in functional state and performance of the cosmonauts. During the postflight period there was a general slowing in the rate of resynchronization of the sleep and wakefulness rhythms.

It is known from the data published in the Soviet and foreign literature that the desynchronization of biological rhythms arising when using modified daily schedules can lead not only to a decrease in the overall and occupational performance of cosmonauts, but also in some cases to the appearance of such diseases as neurosis, hypertonia, ulcers, etc. (Strughold, 1965; Alyakrinskiy, 1969; Aschoff, 1971; Nicholson, 1971). From this point of view the spaceflight study of the characteristics of adaptation of a healthy man to a modified diurnal regime, in our opinion, is of unquestionable scientific and practical interest. In this paper we present results obtained in a study of the work and rest regimes of crew members of the "Soyuz 3-9" in the course of preparations for and implementation of space flight.

Method

The investigations were made in several stages: in the process of direct preparations for flight (20-30 days before); in a launching position (3-15 days before); during space flights (from the second to the 18th days) and during the postflight period (from the third to the tenth day).

Crews of the spaceships "Soyuz 3-9" participated in the investigations. The ordinary Moscow schedule (sleep from 2300 to 0700 hours) was used in the final stage of direct preparations for flights by all crews. In the launching position two variants were used: first -- an ordinary Moscow schedule with brief (±2 hours) sleep and wakefulness shifts ("Soyuz-9" crew); second -- the local time or time displaced relative to the Moscow schedule by -2 hours ("Soyuz 3-8" crews).

During flight of the "Soyuz-3" spaceship the sleep and wakefulness schedule on the first day coincided with the local launching time (sleep from 2100 to 0500 hours), during flight of the "Soyuz 4 and 5" ships it was displaced relative to the local schedule by -3 hours (sleep from 1800 to 0200 hours), and during flights of the "Soyuz 6-8" ships -- by +2 hours, whereas during flight of the "Soyuz-9" ship it was displaced by +9 hours (sleep from 0800 to 1600 hours). On the days which followed, as a result of orbital precession, the rhythm of sleep and wakefulness during flights of the "Soyuz 3-8" ships was constant, whereas in the case of the "Soyuz-9" it was in impulses shifted in the direction of shortening of the cycle by an average of 30 minutes a day. During the postflight period the rhythms of sleep and wakefulness coincided with the launching rhythms.

A study of the sleep and wakefulness regimes was made by evaluating: the functional state of the cerebral cortex and the psychic performance of cosmonauts; dynamics of sleep; diurnal and daytime rhythm of some body functions.

The functional state of the cerebral cortex was studied on the basis of EEG data (left and right frontal-occipital leads), psychic performance was judged from data on the dynamics of simple and complex motor reactions, study of higher nervous activity using test problems, intersection of a point moving across an indicator screen, and simple and complicated 20-sec time tests. The dynamics of sleep were studied by an analysis of motor activity (actograms), the dynamics of pulse and respiration during sleep, records of sleep in the logbooks and reports, specially filled-out forms, etc. The diurnal rhythm of the pulse and respiration under ordinary conditions and during spaceflight were registered each 90-180 minutes on a polygraph; in the launching position and during the post-flight period by hand once to five times a day. Body temperature was registered before and after flight using a thermometer in the left armpit region simultaneously with the pulse and respiration.

Results

In the first stage of study of the sleep and wakefulness regimes the investigations were carried out under ordinary living conditions (for 20 to 30 days prior to the flight). Tables 1 and 2 show that the functional state and performance of cosmonauts during this stage virtually did not differ from the background data. For example, the EEGs for all crews exhibited a well-expressed α-rhythm with a frequency of 9-12 cps and an amplitude of 30-90 μV. In most cosmonauts periodically, and in some constantly, the EEG exhibited bursts of β-rhythm with a frequency of 14-20 cps and an amplitude of 15-25 μV. Pathological rhythms (θ and Δ-waves) in the general EEG were absent. The reactions of the α-rhythm (latent periods of depression and recovery periods) to indifferent, signal and inhibitory stimuli were ordinary. The indices of psychic performance obtained during different periods of wakefulness also corresponded to typical dynamics (maximum in the middle and minimum at the beginning and end of wakefulness). There were no substantial changes during this stage in the dynamics of sleep of cosmonauts. On the basis of the nature of the detected changes it is possible to discriminate three principal types of sleep: the first was characterized by a gradual deepening of sleep over a period of two to three hours, maintenance of deep sleep during the next one to two hours and a gradual decrease in the depth of sleep during the remaining hours; the second was characterized by a rapid deepening of sleep during the first one to two hours and its subsequent decrease during the remaining time; the third was characterized by a gradual deepening of sleep over the first two or three hours, a decrease in depth during the next one to two hours, again a deepening of sleep for two to three hours and its subsequent decrease up to the time of awakening. In addition to the changes in sleep inhibition, during the time of sleep it is also possible to note more frequent one- to two-hour fluctuations, evidently reflecting (Oswald, 1962; Shepoval'nikov, 1966, and others) changes from orthodox to parodoxical sleep and vice versa.

The sufficiently high level of the functional state of higher nervous activity of cosmonauts was also indicated by the results of a study of the diurnal rhythm of some body functions. On the basis of the collected data it is possible to discriminate two principal types of diurnal rhythm: first -- single-phase, with a maximum in the middle of wakefulness and a minimum in the middle of sleep, exhibited by most of the cosmonauts (about 80%). The second type was two-phase, with a maximum at 1100-1200 and 1500-1800 hours and a minimum at 1300-1500 and 0200-0400 hours, observed in 20%.

Both in the first and in the second types it is possible to discriminate two other subtypes: one with a maximum during the early daytime hours of the day (1100-1200 hours) and a second with a maximum during the evening hours (1600-2000 hours). Analysis of the data demonstrated that the first type was encountered more frequently in cosmonauts sleeping at nighttime; the second was encountered more frequently in cosmonauts usually resting during the after-dinner hours. The first subtype (maximum during the early daytime hours) was encountered more frequently in individuals working primarily in a stressed state during the morning and daytime hours, whereas the second was in persons working constantly during the evening hours.

In the dynamics of the functional state of higher nervous activity in cosmonauts in a working position it is possible to distinguish two principal periods: initial or that associated with adaptation to a shift of the diurnal regime by two hours in accordance with the new zonal time, and the prelaunching time proper, governed by neuropsychic stress prior to the flight. During the first period the functional state of higher nervous activity of cosmonauts was influenced substantially by a phase shift in sleep and wakefulness. As a result, most of the cosmonauts (crews of the "Soyuz 3-8") during the course of the several days after arrival at the starting position exhibited distinct disturbances in their general feeling of well-being (complaints of distraction, listlessness, loss of appetite, etc.), a decrease in performance and a deterioration of sleep (Table 3). Unfortunately, the diurnal rhythm of autonomic functions was not investigated at the launching position. But even those indices which were registered in the morning hours of the day (pulse rate and body temperature) quite clearly reflect the step-by-step adaptation of the cosmonauts to the new daily regime. For example, Figure 1 shows that in the first group, adhering to a local regime of sleep and wakefulness, the pulse rate and body temperature (Fig. 1, 1), changing synchronously during the first one to three days, were maintained at low levels (stage of latent restructuring). Beginning with the second to third days, the curves gradually rose to values characteristic at the time of awakening under ordinary conditions (stage of apparent restructuring), and then beginning on the fourth to eighth days remained at this level almost to the very launching (stage of intense restructuring).

Table 1

(1) Динамика ЭЭГ-показателей у экипажей космических кораблей «Союз—3—9» на разных этапах подготовки к полету и послеполетном периоде

(2) Экипажи	(3) Этап	(4) Показатели α-ритма			(5) Скрытый период депрессии α-ритма, сек			(6) Период восстановления α-ритма, сек		
		частота, гц (7)	амплитуда, мкв (8)	индекс, % (9)	простой сигнальный (10)	дифференцировочный (11)	тормозной (12)	простой сигнальный (10)	дифференцировочный (11)	тормозной (12)
«Союз 3»	1	12,0	45,0	50,0	0,22	0,20	0,18	0,91	0,95	0,94
	2	13,0	25,0	40,0	0,19	0,18	0,19	2,40	0,84	0,89
	3	13,3	35,0	25,0	0,18	0,22	0,24	0,98	0,62	0,76
	4	11,0	30,0	25,0	0,30	0,25	0,27	1,53	0,82	1,60
«Союз 4—5»	1	11,4	57,5	69,2	0,26	0,27	0,27	2,10	2,00	2,68
	2	11,3	60,0	65,0	—	—	—	—	—	—
	3	11,6	58,8	54,5	0,25	0,30	0,23	3,30***	2,41**	2,90**
	4	10,4	67,0	68,0	0,24	0,26	0,29	1,80	2,03	2,07
«Союз 6—8»	1	10,3	67,0	85,0	0,25	0,34	0,29	0,79	1,20	1,10
	2	10,6	60,0	69,0	—	—	—	—	—	—
	3	11,1	69,3	40,0	0,33	0,28	0,27	2,10***	3,10***	3,40***
	4	10,2	63,0	72,0	0,24	0,27	0,28	1,32	1,47	1,43
«Союз 9»	1	9,9	69,5	66,0	0,28	0,35	0,37	1,65	2,17	1,78
	2	—	—	—	—	—	—	—	—	—
	3	10,3	70,0	60,0	0,26	0,23	0,19	1,07*	0,75*	1,44*
	4	10,0	57,0	75,0	0,29	0,31	0,20	1,68	2,43	1,40

(13) Примечание. 1 — этап непосредственной подготовки; 2 — этап стартовой подготовки (за 3—5 суток до полета); 3 — этап послеполетный (1—3-и сутки после полета); 4 — фоновые данные. Изменения α-ритма: * — экзальтация; ** — депрессия; *** — экзальтация + депрессия.

1) Dynamics of EEG Indices in Crews of Spaceships "Soyuz 3-9" During Different Stages of Flight Preparations and During the Postflight Period; 2) Crews; 3) Stage; 4) Indices of α-rhythm; 5) Latent period of depression of α -rhythm; 6) Period of recovery of α-rhythm, sec; 7) frequency, cps; 8) amplitude, μV; 9) index; 10) simple signal; 11) differentiated; 12) inhibition; 13) Note. 1) Direct preparation stage; 2) launching

preparations stage (three to five days prior to the flight); 3) postflight stage (first to third day after flight); 4) background data. Changes in α-rhythm: * -- exaltation; ** -- depression; *** -- exaltation + depression.

Table 2

(1) Динамика показателей работоспособности у экипажей «Союз 3—9» на разных этапах подготовки к полету и послеполетном периоде

(2) Пробы	(3) Показатели	(4) «Союз 3» 1	2	3	4	(5) «Союз 4—5» 1	2	3	4
(6) 20-секундные на время, простые	T	0,80	1,60	0,70	1,00	0,72	1,50	2,30	1,50
(7) 20-секундные на время, усложненные	T	1,90	3,90	2.50	3,10	2,58	2,70	4,70	3,40
(8) Простые двигательные реакции на звук	M	190	233	207	200	229	173	243	169
(9) Реакции с выбором на 1-е и 2-е звуковые раздражители	M	432	440	480	416	474	438	489	483
	P	0	0	0,1	0,05	0,01	0,02	0,03	0,01
(10) Исследование высшей нервной деятельности с помощью тестовых задач	M	4020	4000	4130	4800	4930	4170	4050	4500
	P	0	0,03	0,10	0,10	0	0,05	0,10	0,04

(2) Пробы	(3) Показатели	(11) «Союз 6—8» 1	2	3	4	(12) «Союз 9» 1	2	3	4
(6) 20-секундные на время, простые	T	3,20	—	3,20	1,80	2,10	—	1,10	2,40
(7) 20-секундные на время, усложненные	T	2,80	—	3,84	2,20	3,30	—	4,00	1,90
(8) Простые двигательные реакции на звук	M	225	—	231	190	231	—	225	175
(9) Реакции с выбором на 1-е и 2-е звуковые раздражители	M	444	—	508	379	487	—	573	483
	P	0,02	—	0,01	0	0,02	—	0,02	0,02
(10) Исследование высшей нервной деятельности с помощью тестовых задач	M	3820	—	4200	4110	4370	—	3840	4630
	P	0,09	—	0,14	0,09	0,01	—	0	0,15

(13) Примечание. Т — среднее отклонение от заданного интервала, сек; М — математическое ожидание, мсек; Р — вероятность ошибок.

(14) Этапы: 1 — непосредственной подготовки; 2 — стартовой подготовки; 3 — послеполетного периода; 4 — контроль.

1) Dynamics of Indices of Performance for Crew Members of the "Soyuz 3-9" at Different Stages in Flight Preparation and During Postflight Period; 2) Tests; 3) Indices; 4) "Soyuz-3"; 5) "Soyuz 4-5"; 6) 20-second time test, simple: 7) 20-second time test, complicated; 8) Simple motor reactions to sound; 9) Reactions with selection of first and second sonic stimuli; 10) Investigation of higher nervous activity using test problems; 11) "Soyuz 6-8"; 12) "Soyuz-9"; 13) Note. T is mean deviation from stipulated interval, sec; M -- mathematical expectation; P -- error probability; 14) Stages: 1) direct preparation; 2) launching preparation; 3) postflight period; 4) control

Table 3

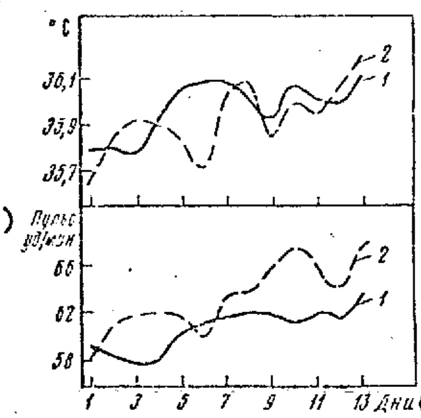
(1) Результаты изучения динамики сна на стартовой позиции

(2) Показатели	(3) 1-я группа				(4) 2-я группа			
	1	2	3	4	1	2	3	4
(5) Длительность сна, час	6,10	7,00	7,00	6,30	6,50	6,30	7,30	6,40
(6) Продолжительность сна к общему времени, %	77	85	88	83	86	83	93	83
(7) Время засыпания, мин	46	23	36	53	30	20	25	45
(8) Спокойные пятиминутки, %	60,0	62,0	64,0	62,7	57,0	56,5	63,0	58,7

(9) Примечание. 1-я группа — исследовалась при режиме со сдвигом на —2 час; 2-я группа — при режиме, близком к московскому. 1 — 1—3-и сутки пребывания на стартовой позиции; 2 — 4—8-е сутки 3 — 9—12-е сутки; 4 — период времени за 1—3 дня до старта.

1) Results of Study of Sleep Dynamics in Launching Position; 2) Indices; 3) first group; 4) second group; 5) Sleep duration, hours; 6) Sleep duration to total time, %; 7) Time required for falling asleep, minutes; 8) Quiet five-minute periods, %; 9) Note. First group -- investigated in regime with shift by -2 hours; second group -- in regime close to Moscow time. 1) first to third day of presence in a launching position; 2) fourth to eighth days; 3) ninth-twelfth days; 4) time period one to three days prior to launching.

(a)



(b)

Fig. 1. Dynamics of pulse rate and body temperature during the initial period of wakefulness of cosmonauts in launching position: 1) groups adhering to local schedule (sleep from 2100 to 0500 hours); 2) groups adhering to Moscow schedule (sleep from 2300 to 0700 hours). A) Pulse, beats per minute; B) Days

During brief adherence to a local schedule ("Soyuz-9" crew), changes in the general feeling of well-being, performance and sleep, although developing, disappeared rapidly. The indices of pulse and body temperature for this group (Figures 1 and 2) changed in waves, but without apparent indications of restructuring.

Several days prior to the launching the dynamics of the functional state of higher nervous activity in both groups show signs of emotional and psychic stress. Tables 1 and 2 show that the indices of the α-rhythm (frequency, amplitude and index) in comparison with the background data were displaced in the direction of a predominance of the high frequencies, evidence (Megun, 1961; Zhirmunskaya, 1963; Peymer, 1960, and others) of a change in the functional state of the central nervous system and cerebral cortex to a higher level. These changes in the dynamics of higher nervous activity of cosmonauts directly prior to the launching can evidently be attributed to a mobilization of the reserve mechanisms of the higher parts of the central nervous system for a more high-quality preparation for flight (Barabash, 1968; Simonov, Frolov, 1970; Gazenko, Alyakrinskiy, 1970; Arkhangel'skiy, et al., 1971, and others). The following also indicate an optimum level of emotional stress during this period: the dynamics of psychic performance (Table 2, 2), fluctuations in pulse rate and body temperature (Fig. 1), secretion of hormones (17-oxycorticosteroids). These matched changes in the EEG, psychic performance, autonomic and hormonal functions, evidently reflect an increase in the overall tone of the central nervous system and especially the activating system of the brain, ensuring optimum functioning of all body systems. In addition, the neuropsychic stress arising directly prior to the launching also exerts a negative influence, reducing the qualitative and quantitative characteristics of the sleep of cosmonauts (Table 3). However, these changes were insignificant and exerted no substantial effect on their functional state and performance.

Analysis of the data collected during space flights made it possible to detect in the dynamics of the functional state and performance of the crews of several periods: first (from the zero to the second day), characterized by a considerable deterioration of the overall state of well-being, performance and sleep of the cosmonauts (from the third to the sixth days) -- recovery and subsequent maintenance of functional state and performance at the optimum level; third (beginning with the seventh and running through the tenth days) -- a gradual decrease in the functional state and performance of the cosmonauts; fourth -- a brief increase in the functional level of the principal body systems ("final burst") in the performance of tasks involved in spaceship landing.

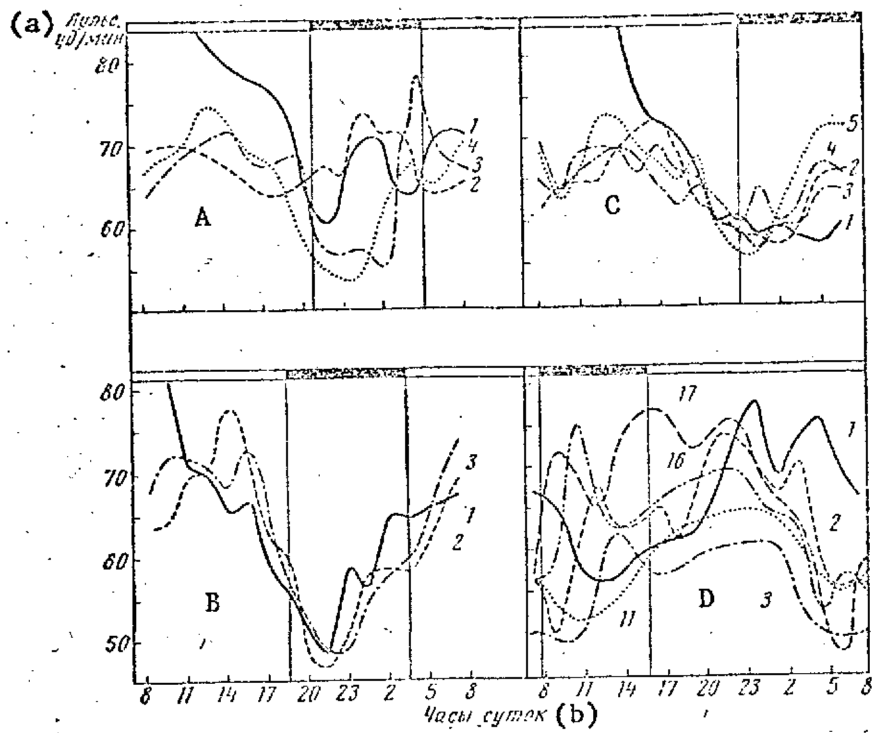


Fig. 2. Diurnal fluctuations in pulse rate in crews of the "Soyuz-3-9" during spaceflight (mean data): A) pulse rate for crew of "Soyuz-3"; B) pulse rate for "Soyuz-4-5" crews; C) pulse rate for "Soyuz-6-8" crews; D) pulse rate for "Soyuz-9" crew; 1, 2, 3, 4, 5, 11, 16, 17 -- days of flight. a) pulse rate, beats per minute; b) hours of day

Due to the small number and different duration of the space flights (from 2 to 18 days) and due to the relatively limited objective material on evaluation of the functional state of higher nervous activity and performance in flight it is presently impossible to determine the duration of these periods. These periods were evidently fully observed in their full scope only during flight of the "Soyuz 9" crew; in other crews they were partially observed. The first period was observed in all cosmonauts. It was characterized by a distinct disturbance in the coordination of movements, an increase in the time required for performing simple and complex operations, and an increase in erroneous operations (Nefedov, et al., 1969; Yegorov, Kakurin, 1969; Gazenko, Alyakrinskiy, 1970; Vorob'yev, 1970, and others). During this period the decrease in performance was accompanied by a considerable deterioration in the feeling of well-being of these cosmonauts (sensation of rush of blood to the head, sensation of the body being turned upside down, nausea, discomfort in the abdomen at the time of significant movements, etc.) and sleep disturbance in quantitative and qualitative respects. During this period the low level of the functional state of the central nervous system and performance of the crews was indicated by the results of observations of behavior of cosmonauts by television (Gazenko, Alyakrinskiy, 1970, Vorob'yev, et al., 1970, and others) and the indices of registry of autonomic functions (Fig. 2). Figure 2 shows that the pulse rate curves, independently of the employed diurnal regime, for all crews on the first day changed approximately identically -- increasing sharply at the time of launching (by 150-200%); they slowly (with insignificant fluctuations) decreased up to onset of the next day. On the second day the curves dropped off somewhat or were distorted. On the following days, if the sleep and wakefulness regime coincided or differed insignificantly from the ordinary regime ("Soyuz-3-8" crews), the curves were in accordance with the employed diurnal regime, in this case exhibiting a distinct tendency to a deepening of values during sleep (which indirectly indicated its improvement) and their rise in the middle of wakefulness (improvement in functional state). For the "Soyuz-4 and 5" crews the curves also were gradually shifted to the right in the opposite direction in comparison with orbital precession and the used diurnal schedule, but in the direction of their correspondence with the launching regime, but for the "Soyuz 6-8" crews, on the other hand, there was a shift to the left, coinciding with orbital precession, the launching and flight schedules. For the "Soyuz-9" crew, despite a six to eight hour shift, the pulse curves already on the second to third day assumed a shape corresponding to the usual (terrestrial) diurnal schedule and thereafter persisted at this level with small fluctuations during the morning and daytime hours (Fig. 2,D).

On approximately the second to fourth days all the crews, according to objective and subjective data, exhibit improvement in the functional state of the higher parts of the central nervous system and performance, although unpleasant sensations still occur in the body (rush of blood to the head, sensation of discomfort at the time of abrupt movements, etc.). On these days there was also a considerable improvement in sleep, averaging five to six hours per day. The cosmonauts exhibit high spirits and show a desire and capacity for performing complex, highly coordinated activity.

Approximately on the sixth to eighth days the performance of the cosmonauts ("Soyuz-9" crew) again deteriorates. Immediately after sleep the general feeling of well-being and the functional level of the principal systems are still rather high. However, fatigue develops as the work program is implemented, attaining maximum values by the end of wakefulness.

During this period restoration of performance of these cosmonauts was attained by the introduction of a day off (eleventh day) and an increase in the rest period during the course of the workday. During this period the pulse curves (Fig. 2), although they retained their normal rhythm, were reduced in comparison with the first days. During this period the dynamics of the sleep for these crew members was virtually the same as on the first day, averaging five to seven hours, which is obviously inadequate for recovery of the performance of cortical cells lost during the course of wakefulness, since all this favored a gradual exhaustion of the nervous system of these cosmonauts.

Not long prior to ending the flight (15th-17th day) the general feeling of well-being and performance of the cosmonauts increase somewhat. The pulse curves (see Fig. 2) during the time of wakefulness are considerably higher, but during the time of sleep are lower than on other flight days; this is apparently evidence of a partial normalization of the "sleep-wakefulness" cycles of cosmonauts. Psychologically this increase in the functional level of the principal systems of cosmonauts can be attributed, on the one hand, to the closeness of spaceflight termination and activation of the reserve capabilities of the nervous system ("final burst"), and on the other hand, a decrease in the physical and psychic load, the introduction of additional rest, and also deepening of sleep due to the use of soporific drugs, etc.

After completing space flights all crew members on the first day exhibited approximately similar changes in the functional state of higher parts of the central nervous system and psychic performance. For example, the most characteristic disturbances on the first day after flight were: general weakness, increased fatigability despite insignificant physical loads, changes in the coordination of movements and gait, instability in mood, a sensation of pressure on the body surface by an additional load up to two units, etc. (Gazenko, Alyakrinskiy, 1970; Kakurin, Lebedev, 1971, and others). On the days which followed, depending on flight duration, these changes gradually disappeared. During flights up to three days they passed in the course of several hours and minutes; in the course of flights up to four to five days they passed during the course of several days (one-three days); but after an 18-hour flight -- in the course of eight to fourteen days, or more.

In addition to the already mentioned disturbances, associated for the most part with the action of weightlessness and neuropsychic stress, during the postflight period there were also deviations in the "sleep-wakefulness" rhythm of the cosmonauts, expressed in a change in the functional state of higher nervous activity and performance during the course of the day, sleep disturbance, shifts in the daytime and diurnal rhythm of the principal indices. For example, Tables 1 and 3 show that most of the EEG indices for crews on the first to third days were modified in the direction of a predominance of high frequencies; this might be attributable to a high functional level of the cerebral cortex. However, the polyrhythmicity of the EEG, with the presence of bursts of slow waves (θ, σ), phase changes (exaltation and stagnant depression of the dominating rhythm), as well as deterioration of most psychophysiological tests (Tables 2 and 3), indicate an attenuation of both excitation and inhibition processes. These changes were less well expressed in members of the "Soyuz-3" crew, who during spaceflight adhered to the ordinary schedule of sleep and wakefulness; they were somewhat stronger in members of the "Soyuz 4-8" crews, adhering to schedules with small degrees of displacement, and were most clearly expressed in "Soyuz-9" crew members, whose diurnal regime over a prolonged period was displaced relative to an ordinary schedule by four to eight hours.

Table 4

(1) Результаты изучения динамики сна в послеполетном периоде

(2) Экипажи	(3) Дни	(4) Длительность сна		(5) Время засыпания	(6) Спокойные пятиминутки
		час, мин (7)	% к общему времени (8)	мин (9)	%
«Союз 3» (10)	1	5,20	64	95	48
	2	7,20	86	20	73
	Контроль (11)	7,40	96	20	60
«Союз 4—5»	1	5,40	75	51	72
	2	6,10	81	75	74
	3	7,20	89	59	75
	Контроль	7,50	94	17	64
«Союз 6—8»	1	5,30	83	24	74
	2	5,40	85	37	69
	3	6,30	89	35	66
	Контроль	7,10	90	20	65
«Союз 9»	3	5,40	63	45	44
	5	6,10	73	65	57
	7	8,00	93	30	66
	Контроль	7,30	94	20	66

1) Results of Study of Sleep Dynamics During Postflight period; 2) Crews; 3) Days; 4) Sleep duration; 5) Time required for falling asleep; 6) Quiet five-minute periods; 7) hours, minutes; 8) % of total time; 9) minutes; 10) "Soyuz"; 11) control

During the postflight period there were sleep disturbances (Table 4) expressed in difficulties in falling asleep (from 40 to 80 minutes), periodic awakenings (two to four times per night) and a decrease in total sleep duration (up to four-six hours). In the "Soyuz 3-8" crews these disturbances disappeared on the second to third day; for the "Soyuz-9" crew they persisted for a period of six to ten days. Sleep recovery for all crews coincided with improvement in the functional state of higher parts of the central nervous system and psychic performance of the cosmonauts.

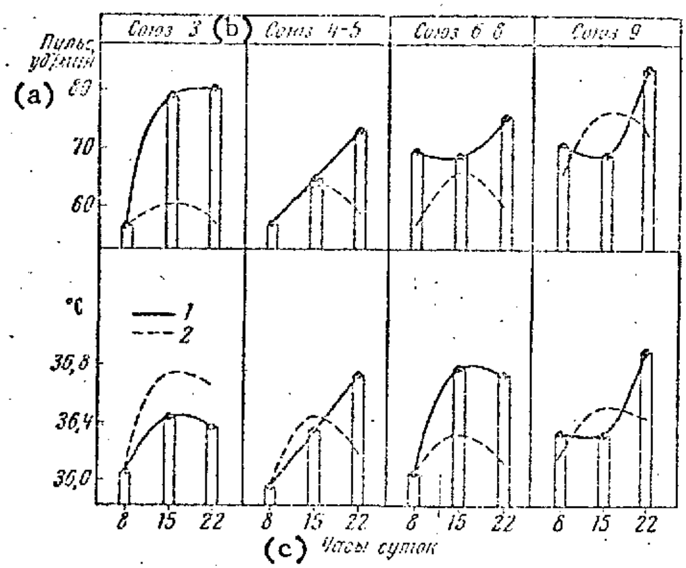


Fig. 3. Dynamics of pulse rate and body temperature for crews of the spaceships "Soyuz 3-9" during the postflight period (mean data for one to three days): 1) postflight period; 2) control. a) Pulse rate, beats/min; b) Soyuz; c) Hours of day

During the postflight period there were also disturbances in autonomic functions. For example, Fig. 3 shows that the pulse and body temperature curves for crews adhering during spaceflight to modified diurnal regimes were distorted on the first to third day. For the "Soyuz-4-8" crews the diurnal rhythm disappeared on the second to third days, whereas for the "Soyuz-9" crew restructuring of the indices in accordance with the new regime was even completed during the course of eight to ten days. This slowing of restructuring of the principal functions in the "Soyuz-9" crew to an ordinary diurnal regime was evidently caused by manifestations of desynchronosis developing as a result of frequent migration of periods of sleep and wakefulness during flight.

Thus, the changes noted in the "Soyuz 3-9" crews were associated with exposure to a combination of extremal factors, of which the most important were: weightlessness, neuropsychic stress and diurnal regimes of the migrating type.

Proceeding on the basis of the materials cited above it can be postulated that migrating diurnal regimes are tolerated by man with considerably greater difficulty than static regimes and should be used over a limited period (two or three days). During the postflight period the sleep and wakefulness regime of the cosmonauts to all intents and purposes should not differ significantly from the flight schedule. Resynchronization to an ordinary diurnal regime must take place after eliminating the principal impairments and recovery of nervous system performance.

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